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Automated pumping station for reuse of irrigation runoff water

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Common practice in the United States has been to allow surface runoff from irrigation systems to leave the farm and return to the canal system or natural stream. Currently, however, because of increased water demand, the trend is to collect and reuse this runoff water. Reuse of collected runoff water increases overall farm irrigation efficiency and decreases the total amount of water that needs to be pumped or delivered to the farm. Pollution of natural streams is reduced by stopping the flow of silt and nutrients that may be contained in surface runoff water. Other benefits such as reducing drainage costs and improved weed control accrue from multiple use of return systems. These systems are readily adapted to automation, and automated or semiautomated pumping stations can be used advantageously in many return flow systems.

Operating Principles for Reuse of Water:

The return flow system collects the runoff water from one or more fields and returns it to the point on the farm where it may be used effectively and efficiently. This water may be:
(1) returned to the same field that is generating runoff, (2) applied to higher lying fields, or (3) applied to a lower lying field. A reservoir large enough to store the runoff from two or more irrigation sets is required if the collected runoff water is handled as a separate supply. This water can then be pumped for a given irrigation set and may be used on either higher or lower lying fields. Automatic control of these larger storage systems utilizes water level sensing devices.

Automatically cycled pumping stations, controlled by water level sensing, are used if the runoff water is returned immediately as it occurs.

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These systems return the runoff water to either the set generating the run-off or to another area and require very little reservoir capacity.

An efficient method of using the collected runoff water for surface irrigation systems is by pumping it to provide a cutback stream (1).[+] To do this, water from the return system is used to supplement the original supply while water is advancing to the end of the irrigation furrow. When runoff begins, pumping from the collected supply is stopped. This results in a high initial or primary flow followed by a reduced or cutback secondary flow in each furrow. This system can be manually started and the length of pumping time controlled by a time clock. Fully automatic operation is possible if the irrigation water distribution to the field is also fully automatic. Smaller pumping equipment and reservoirs are required for this system than for most other reuse systems. Using the return system in this manner can result in higher surface irrigation efficiencies than are normally obtained.

The Pumping Station

Pumping stations for return flow systems consist of the collection reservoir, pump sump, pump and controls, and the pipeline to return the water to the irrigation system. The collecting reservoir can serve as the pump sump or a separate sump can be used. The size of the sump depends upon the method of handling the collected water. Large sumps are made with heavy construction equipment, while small sumps can be made with a tractor-mounted backhoe. The inflow should be piped into the sump and the sump itself diked to prevent erosion by inflowing water. The pump stand is usually made of either concrete pipe, block, or a supporting structural frame. Small sumps can be made entirely from precast concrete pipe sections or precast concrete tanks. The sump design requirements for efficient intake conditions are given by Shahroody and Davis (3).

The suction side of the pumping station consists of a strainer, foot valve and the suction pipe. The discharge side will have a valve and an easily disconnected section so that the pump may be removed without emptying the pipeline. Priming is not a problem with these pumping stations. Where the runoff water is returned to a higher elevation, the pipeline is full of water, thus creating back pressure on the foot valve and supplying a continuous prime to the pump. Incoming water to the pump sump may need to be screened to remove debris too large to pass through the pump.

Controls

Automatic controls for return systems are generally of two types - water level sensing controls or time controls. Water level sensing controls are either float-operated switches or electrical sensors which use the water as a conductor in the circuit. These water level sensing systems operate by starting the pump at high water level and stopping it again after the water level is lowered. The float-operated control system usually consists of a float which slides through a control sleeve on a rod. The pump is turned on by a switch when the float reaches the high level and is turned off by the

Numbers in parentheses refer to appended references.

same mechanism when the float reaches the lower level. Adjustable upper and lower stops on the float rod are used to set the "on" and "off" levels. These stops operate mechanical or magnetic switches which start and stop the pump motor. If the motor is larger than about 2 hp, the switch is used to operate the larger magnetic starter. Float-operated controls sometimes give trouble because the float may bind in the slide mechanism, or the mechanically operated switch may not always work. Problems with the mechanical switch can be overcome by using a tilting mercury switch turned on and off by the float rod. Mercury power relays are more reliable than mechanical relays for controlling motors or operating magnetic starters. These float-operated systems can also be run with a cable mechanism to eliminate binding of the float rod in the slide assembly. A simple float switch setup is shown in Figure 1 a. A diagram of the magnetic switch is shown in Figure 1 b.

Electrode-operated controls utilize two electrodes in a conductive circuit with water serving as the conductive medium. A low resistance circuit is energized when the water level rises to the upper electrode which controls the "on" pump position. As the water level drops below the upper electrode, a higher resistance circuit, making contact through the water and the suction pipe, keeps the control circuit energized. When the water level falls below the lower electrode, the holding circuit is de-energized and pumping stops until the water level rises again to the upper electrode. The sensing electrodes may be either solid electrodes, Figure 1 d, or small contacts mounted on insulated electrical conductors, Figure 1 c. The electrodes must be located in the pump sump so that they are protected from inflowing water splash, which can cause premature operation. The electrode control is also commercially available with a solid switch in which the switching is accomplished with a silicon controlled rectifier circuit rather than an energized relay circuit, Figure 1 d. An electrode-controlled system is shown in Figure 2.

Both the float-operated control and the electrode control can be used to start pump operation at a lower limit rather than an upper limit. In these systems the runoff water is pumped to keep a set water level in an elevated reservoir. The control signal in this case is transmitted to the pumping station either by wire or by radio. Pressure-operated switches, similar to those used in many domestic water systems in the United States can also be used in this system. The pressure controls have adjustable tension contacts which can be set for a given pressure differential, thus turning the pump on when the water level in the upper reservoir falls to a preset level.

Automatic control of return system pumping stations also can be obtained with timing clocks or a timing clock in conjunction with a runoff flow sensor. Return systems using runoff water to obtain cutback streams can be automated in this manner if they are used with an automated delivery system (2). Clock timed delivery systems are most adaptable, since runoff pumping can be synchronized without signal transfer from the delivery system.

Automatic pumping stations using internal combustion engines as a power source can be operated with virtually the same type of water level sensing equipment. In this case the control signal operates a relay which, in turn, energizes the starting system on the engine. Protective devices for sensing loss of oil pressure, high engine temperature, loss of prime, etc., are required on these installations.

Semiautomated pumping stations are started manually and are operated through a timeclock which stops the pumping at the desired time.

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Figure 1. Water level sensing controls for automatic irrigation runoff return systems. (a) Float operated mechanical switch. (b) Diagram of magnetically operated reed switch showing, 1) a magnetic float, d 2) the magnetic reed switch. (c) Cutaway of a sensing electrode. (d) id state switch with solid upper and lower sensing electrodes.

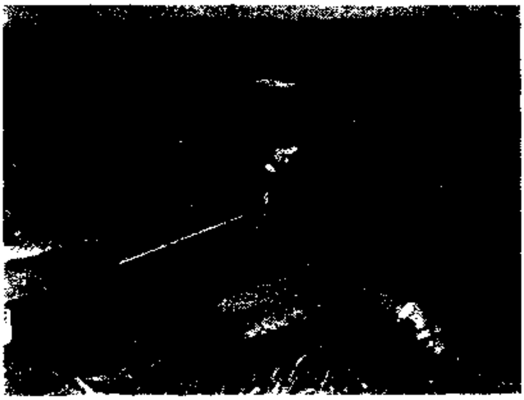

Figure 2. Automatic return system controlled by an electrode water level sensing device. The technician is holding the electrode.